

Fits and Tolerances

Grades of Tolerances IT1 to IT16

Grade	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
Number of units	Not stated				71	101	161	251	401	641	1001	1601	2501	4001	6401	10001
Diameters mm	Tolerance μ , ($\mu = 0.001$ mm)															
More than	Up to															
1	3	1½	2	3	4	5	7	9	14	25	40	60	90	140	250	400
3	6	1½	2	3	4	5	8	12	18	30	48	75	120	180	300	480
6	10	1½	2	3	4	6	9	15	22	36	58	90	150	220	360	580
10	18	1½	2	3	5	8	11	18	27	43	70	110	180	270	430	700
18	30	1½	2	4	6	9	13	21	33	52	84	130	210	330	520	840
30	50	2	3	4	7	11	16	25	39	62	100	160	250	390	620	1000
50	80	2	3	5	8	13	19	30	46	74	120	190	300	460	740	1200
80	120	3	4	6	10	15	22	35	54	87	140	220	350	540	870	1400
120	180	4	5	8	12	18	25	40	63	100	160	250	400	630	1000	1600
180	250	5	7	10	14	20	29	46	72	115	185	290	460	720	1150	1850
250	355	6	8	12	16	23	32	52	81	130	210	320	520	810	1300	2100
315	400	7	9	13	18	25	36	57	89	140	230	360	570	890	1400	2300
400	500	8	10	15	20	27	40	63	97	155	250	400	630	970	1550	2500

$$\text{Tolerance unit } i = 0.45 \sqrt[3]{D} + 0.001 D, \text{ where}$$

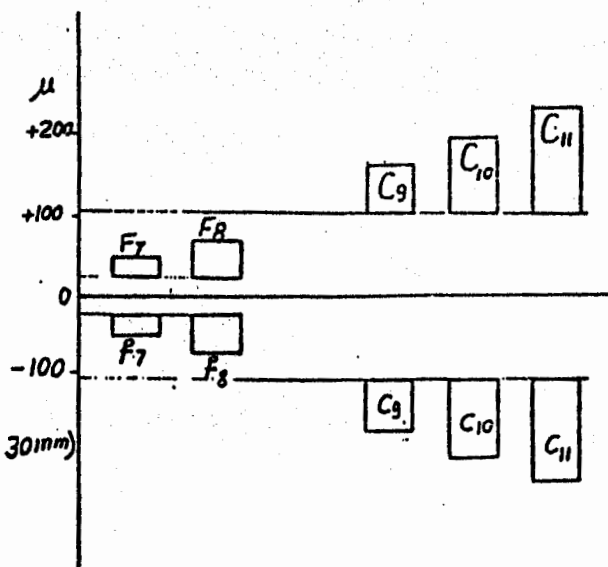
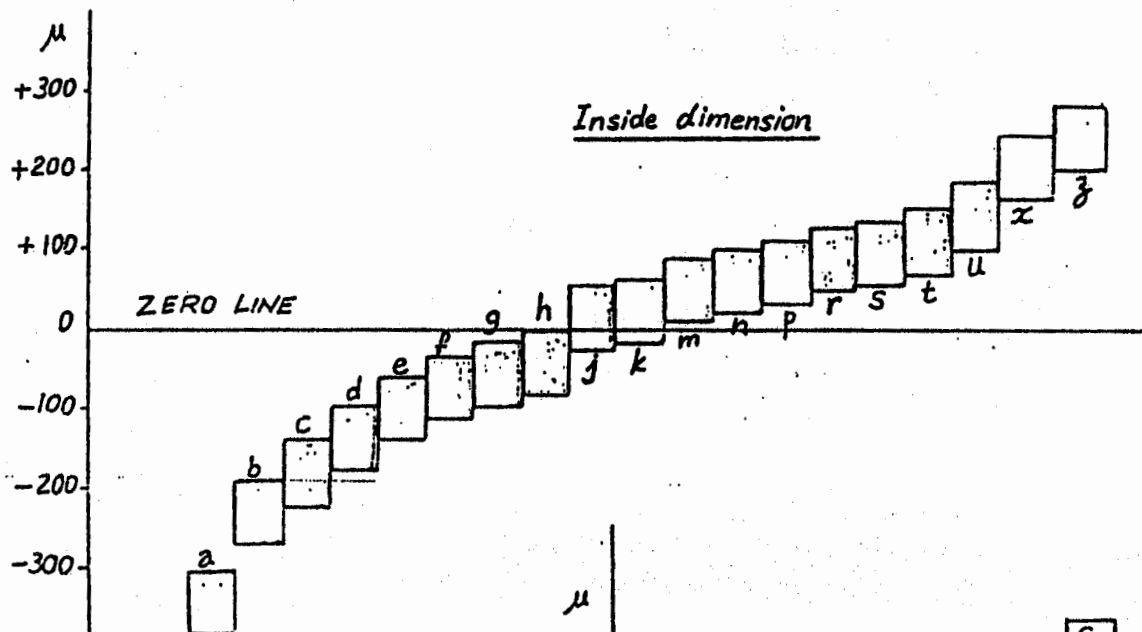
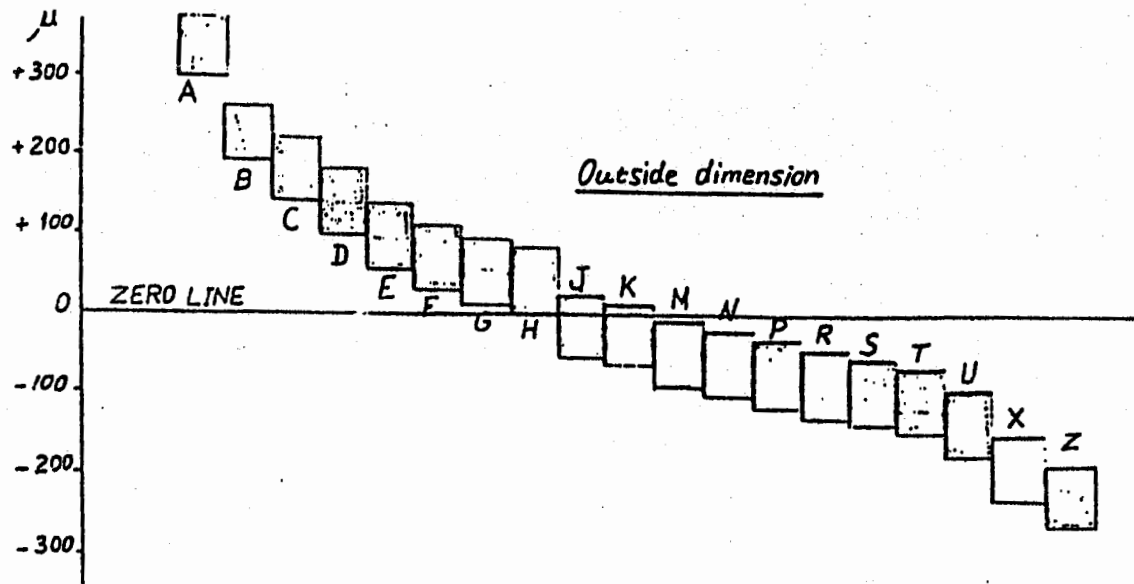
D = Geometric mean diameter for each range in mm

IT1 to IT7 used for gauges
 IT5 to IT11 used for general fits
 IT9 to IT14 used for general workshop tolerances
 IT12 to IT16 used for general large tolerances and not for fits.

* An extract from DIN 7150, 7151

MAXIMUM ROOT MEAN SQUARE (R. M. S.) VALUES OF SURFACE ROUGHNESS
CORRESPONDING TO FUNDAMENTAL TOLERANCE GRADES.

PRODUCTION PROCESSES.	TOLERANCE GRADES.	DIAMETER OR LENGTH (MM.)														
		MORE THAN	1	3	6	10	18	30	50	80	120	180	250	315	400	
		UP TO	3	6	10	18	30	50	80	120	180	250	315	400	500	
MACHINE LAPPING, FINE GRINDING, HIGH QUALITY BORING.	IT 5	0.2				0.4			0.8			- R.M.S. = 1.6				
GRINDING, FINE HONING.	IT 6		0.4				0.8				1.6				32	
HIGH QUALITY TURNING, HONING, BROACHING.	IT 7	0.4			0.8			1.6				3.2				
FINE TURNING, FINE BORING, REAMING.	IT 8	0.8				1.6					3.2			6.3		
TURNING, BORING.	IT 9		1.6				3.2				6.3				12.5	
SHAPING, MILLING, ROLLING EXTRUSION.	IT 10			3.2				6.3				12.5				
ROUGH TURNING, DRILLING PRECISION TUBE DRAWING.	IT 11	3.2				6.3						12.5		25		
LIGHT PRESS WORK. TUBE DRAWING	IT 12	6.3					12.5				25				50	
GENERAL PRESS WORK, TUBE ROLLING.	IT 13			12.5					25				50			
DIE CASTING.	IT 14	12.5			25									100		



• Change of tolerance zone width as the grade changes. (size = 30mm)

BASIC HOLE SYSTEM															
H6															
Diameters		H5	S H A F T												
			Running fit				Elide fit	Push fit	Wrapping fit	Drive fit	Medium force fit	FORCE fit			
From	to	H5	e7	f6	g5	h5	j5	k5	m5	n5	p5	r5	s5	t5	u5
1	3	+7 0	-14 -23	-7 -14	-3 -8	0 -5	+4 0	- -	+7 +2	+11 +6	+14 +9	+17 +12	+20 +15	- -	+23 +18
3	6	+8 0	-20 -32	-10 -18	-4 -9	0 -5	+4 -1	- -	+9 +4	+13 +8	+17 +12	+20 +15	+24 +19	- -	+28 +23
6	10	+9 0	-25 -40	-13 -22	-5 -11	0 -6	+4 -2	+7 +1	+12 +6	+16 +10	+13 +15	+25 +19	+29 +23	- -	+34 +28
10	14	+11	-32	-16	-6	0	+5	+9	+15	+20	+26 +18	+31 +23	+36 +28	- -	+41 +33
14	18	0	-50	-27	-14	-8	-3	+1	+7	+12	+26 +18	+31 +23	+36 +28	- -	+41 +33
18	24	+13	-40	-20	-7	0	+5	+11	+17	+24	+31	+37	+44	-	+50 +41
24	30	0	-61	-33	-16	-9	-4	+2	+8	+15	+22	+28	+35	+50 +41	+57 +48
30	40	+16	-50	-25	-9	0	+6	+13	+20	+28	+37	+45	+54	+59 +41	+71 +60
40	50	0	-75	-41	-20	-11	-5	-2	+9	+17	+22	+34	+43	+65 +54	+81 +70
50	65	+19	-60	-30	-10	0	+6	+15	+24	+33	+44	+54 +41	+66 +53	+79 +66	+100 +87
65	80	0	-90	-49	-23	-13	-7	+2	+11	+20	+32	+56 +43	+72 +59	+88 +75	+115 +102
80	100	+22	-72	-36	-12	0	+6	+18	+28	+38	+52	+66 +51	+86 +71	+106 +91	+139 +124
100	120	0	-107	-58	-27	-15	-9	-3	+13	+23	+37	+69 +53	+94 +79	+119 +104	+159 +144

BASIC HOLE SYSTEM

H6

Diameters		HOLE	S H A F T												
			Running fit				Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit	Force fit			
From	to	H6	e7	f6	g5	h5	j5	k5	m5	n5	p5	r5	s5	t5	u5
120	140	+25	- 85	-43	-14	0	+ 7	+21	+35	+45	+61	+ 81 + 63	+110 + 92	+140 +122	+188 +170
140	160	0	-125	-68	-32	-18	-11	+ 3	+15	+27	+43	+ 83 + 65	+118 +100	+152 +134	+208 +180
160	180											+ 86 + 68	+126 +108	+164 +146	+228 +210
180	200	+29	-100	-50	-15	0	+ 7	+24	+37	+51	+70	+ 97 + 77	+142 +122	+186 +166	+266 +236
200	225	0	-146	-79	-35	-20	+13	+ 4	+17	+31	+50	+100 + 80	+150 +130	+200 +180	+278 +259
225	250											+104 + 84	+160 +140	+216 +196	+304 +284
250	280	+32	-110	-56	-17	0	+ 7	+27	+43	+57	+79	+117 + 94	+181 +158	+241 +218	+338 +315
280	315	0	-162	-88	-40	-23	+16	+ 4	+20	+34	+56	+121 + 98	+193 +170	+263 +240	+373 +350
315	355	+36	-125	-62	-18	0	+ 7	+29	+46	+62	+87	+133 +108	+215 +190	+293 +268	+415 +390
355	400	0	-180	-96	-43	-25	-18	+ 4	+21	+37	+62	+139 +114	+233 +208	+319 +294	+360 +335
400	450	+40	-135	-68	-20	0	+ 7	+32	+50	+67	+95	+153 +126	+259 +232	+357 +330	+517 +490
450	500	0	-198	-108	-47	-27	-20	+ 5	+23	+40	+68	+159 +132	+279 +252	+387 +360	+567 +540

BASIC HOLE SYSTEM H7												
Diameters		HOLE	S H A F T									
			R u n n i n g f i t									
From	to	H7	a9	b9	b8	c9	c8	d9	d8	e8	f7	g6
1	3	+9 0	-270 -295	-140 -165	-140 -154	-60 -85	-60 -74	-20 -45	-20 -34	-14 -28	-7 -16	-3 -10
3	6	+12 0	-270 -300	-140 -170	-140 -158	-70 -100	-70 -88	-30 -60	-30 -48	-20 -38	-10 -22	-4 -12
6	10	+15 0	-180 -316	-150 -186	-150 -172	-80 -116	-80 -102	-40 -76	-40 -62	-25 -47	-13 -28	-5 -14
10	14	+18 0	-290 -333	-150 -193	-150 -177	-95 -138	-92 -122	-50 -93	-50 -77	-32 -59	-16 -34	-6 -17
14	18											
18	24	+21 0	-300 -352	-160 -212	-160 -193	-110 -162	-110 -143	-65 -117	-65 -98	-40 -75	-20 -41	-7 -20
24	30											
30	40	+25 0	-310 -372	-170 -232	-170 -209	-120 -162	-120 -159	-80 -142	-80 -119	-50 -89	-25 -50	-9 -25
40	50											
50	65	+30 0	-340 -414	-190 -264	-190 -236	-140 -214	-140 -185	-100 -174	-100 -146	-60 -106	-30 -60	-10 -29
65	80											
80	100	+35 0	-380 -467	-220 -307	-220 -274	-170 -257	-170 -224	-120 -207	-120 -174	-76 -126	-36 -71	-12 -34
100	120											
120	140	+40 0	-460 -560	-260 -360	-260 -323	-200 -300	-200 -263	-145 -245	-145 -208	-85 -148	-43 -83	-14 -39
140	160											
160	180											
180	200	+46 0	-660 -775	-340 -455	-340 -412	-240 -355	-240 -312	-170 -285	-170 -242	-100 -172	-50 -96	-15 -44
200	225											
225	250											
250	280	+52 0	-920 -1050	-480 -610	-480 -561	-300 -430	-300 -381	-190 -320	-190 -271	-110 -191	-56 -108	-17 -49
280	315											
315	355	+57 0	-1200 -1340	-600 -740	-600 -689	-360 -500	-360 -449	-210 -350	-210 -299	-125 -214	-62 -119	-15 -54
355	400											
400	450	+63 0	-1500 -1655	-760 -915	-760 -857	-440 -595	-440 -537	-230 -380	-230 -327	-135 -232	-68 -131	-20 -60
450	500											

BASIC HOLE SYSTEM (H7)

Diameters		S H A F T									
		Slide fit	Push fit	Wringing fit	Slide fit	Medium force fit	Force fit				
		h6	j5	k6	m6	n6	p6	r6	s6	t6	u6
From	to										
1	3	0 - 7	+ 6 - 1	- -	+ 9 + 2	+13 + 5	+ 16 + 9	+ 19 + 12	+ 22 + 15	- -	+ 25 + 18
3	6	0 - 8	+ 7 - 1	- -	+12 + 4	+16 + 8	+ 20 + 12	+ 23 + 15	+ 27 + 19	- -	+ 31 + 25
6	10	0 - 9	+ 7 - 2	+10 + 1	+15 + 6	+19 +10	+ 24 + 15	+ 28 + 19	+ 32 + 23	- -	+ 37 + 28
10	14	0	- 8	+12	+18	+23	+ 29	+ 34 + 23	+ 39 + 28	- -	+ 44 + 33
14	18	-11	- 3	+ 1	+ 7	+12	+ 18	+ 34 + 23	+ 39 + 28	- -	+ 44 + 33
18	24	0	+ 9	+15	+21	+28	+35	+ 41 + 28	+ 48 + 35	- -	+ 54 + 41
24	30	-13	- 4	+ 2	+ 8	+15	+ 22	+ 41 + 28	+ 48 + 35	+ 54 + 41	+ 61 + 48
30	40	0	+11	+18	+25	+33	+ 42	+ 50 + 34	+ 59 + 43	+ 64 + 48	+ 67 + 60
40	50	-16	- 5	+ 2	+ 9	+17	+ 26	+ 50 + 34	+ 59 + 43	+ 70 + 54	+ 86 + 70
50	65	0	+12	+21	+30	+39	+ 51	+ 60 + 41	+ 72 + 53	+ 85 + 66	+106 + 87
65	80	-19	- 7	+ 2	+11	+20	+ 32	+ 62 + 43	+ 78 + 59	+ 84 + 75	+121 +102
80	100	0	+13	+25	+33	+45	+ 59	+ 73 + 51	+ 95 + 71	+113 + 91	+146 +124
100	120	-22	- 9	+ 3	+13	+23	+ 37	+ 76 + 54	+101 + 79	+126 +104	+156 +144
120	140	0	+14	+28	+40	+52	+ 68	+ 88 + 63	+117 + 92	+147 +122	+195 +170
140	160	-25	-11	+ 3	+15	+27	+ 43	+ 90 + 65	+125 +100	+159 +134	+211 +190
160	180							+ 93 + 68	+133 +108	+171 +146	+225 +210
180	200	0	+16	+33	+46	+60	+ 79	+106 + 77	+151 +122	+195 +166	+265 +236
200	225	-29	-13	+ 4	+17	+31	+ 50	+109 + 80	+159 +130	+209 +180	+237 +258
225	250							+113 + 84	+169 +140	+225 +190	+313 +284
250	280	0	+16	+36	+52	+66	+88	+126 + 94	+190 +158	+250 +218	+347 +315
280	315	-32	-16	+ 4	+20	+34	+ 56	+130 + 98	+202 +170	+272 +240	+382 +350
315	355	0	+18	+40	+57	+73	+ 98	+144 +108	+226 +190	+304 +268	+426 +390
355	400	-36	-18	+ 4	+21	+37	+ 62	+150 +114	+244 +208	+330 +294	+471 +435
400	450	0	+20	+45	+63	+80	+108	+166 +128	+252 +212	+338 +300	+530 +490
450	500	-40	-20	+ 5	+23	+40	+ 68	+172 +132	+262 +222	+360 +320	+580 +540

BASIC HOLE SYSTEM H8

Diameters		Hole	S H A F T													
			Running fit				Slide fit		Push fit	Wringing fit	Drive fit	Medium force fit	Force fit			
			d10	e9	f8	h8	h7	j7	k7	m7	n7	p7	r7	s7	t7	u7
1	3	+14 0	-20 -60	-14 -39	-7 -21	0 -14	0 -9	+7 -2	-0 -0	-0 +2	+15 +6	+18 +9	+21 +12	+54 +15	-	+27 +18
3	6	+18 0	-30 -78	-20 -50	-10 -28	0 -18	0 -12	+9 -3	-	-	+20 +8	+24 +12	+27 +15	+31 +19	-	+35 +23
5	10	+22 0	-40 -98	-25 -61	-13 -35	0 -22	0 -15	+10 -5	+16 +1	+21 +6	+25 +10	+30 +15	+34 +19	+38 +23	-	+43 +28
10	14	+27 0	-50 -120	-32 -75	-16 -43	0 -27	0 -18	+12 -6	+19 +1	+25 +7	+30 +12	+36 +18	+41 +23	+46 +28	-	+51 +33
14	18															
18	24	+33 0	-65 -149	-40 -92	-20 -53	0 -33	0 -21	+13 -8	+23 +2	+29 +8	+36 +15	+43 +22	+49 +28	+56 +35	-	+62 +41
24	30															
30	40	+39 0	-80 -180	-50 -112	-25 -64	0 -39	0 -25	+15 -10	+27 +2	+34 +9	+42 +17	+51 +26	+59 +34	+68 +43	+73 +54	+85 +60
40	50															
50	65	+46 0	-100 -220	-60 -134	-30 -76	0 -46	0 -30	+18 -12	+32 +2	+41 +11	+50 +20	+62 +32	+71 +41	+83 +53	+96 +68	+117 +87
65	80															
80	100	+54 0	-120 -260	-72 -159	-36 -90	0 -54	0 -36	+20 -15	+38 +3	+48 +13	+58 +23	+72 +37	+85 +54	+106 +79	+126 +104	+159 +144
100	120															
120	140												+103 +63	+132 +92	+162 +122	+210 +170
140	160	+63 0	-145 -305	-85 -185	-43 -106	0 -63	0 -40	+22 -18	+43 +3	+55 +15	+67 +27	+83 +43	+105 +65	+140 +100	+174 +134	+230 +190
160	180												+108 +68	+148 +108	+186 +146	+250 +210
180	200												+123 +77	+168 +122	+212 +168	+282 +236
200	225	+72 0	-170 -335	-100 -215	-50 -122	0 -72	0 -46	+25 -21	+50 +4	+67 +17	+77 +31	+96 +50	+126 +80	+176 +130	+226 +180	+304 +258
225	250												+130 +84	+186 +140	+242 +196	+330 +284
250	280												+146 +94	+210 +158	+270 +218	+367 +315
280	300	+81 0	-190 -400	-110 -240	-56 -137	0 -81	0 -52	+26 -26	+56 +4	+72 +20	+86 +34	+108 +56	+150 +98	+222 +170	+292 +240	+402 +350
315	355	+89 0	-210 -440	-125 -265	-62 -151	0 -89	0 -57	+29 -28	+61 +4	+78 +21	+94 +37	+119 +62	+165 +108	+247 +190	+327 +268	+447 +390
355	400												+171 +114	+265 +208	+355 +294	+492 +435
400	450												+189 +126	+295 +232	+395 +330	+552 +480
450	500	+97 0	-230 -483	-135 -290	-68 -165	0 -97	0 -63	+31 -32	+68 +5	+86 +23	+103 +40	+131 +68	+195 +132	+315 +252	+423 +360	+603 +540

BASIC SHAFT SYSTEM h 6												
Diame- ters	Shaft	H O L E										
		R U N N I N G F I T S										
From	to	h ₆	A ₉	B ₉	B ₈	C ₉	C ₈	D ₉	D ₈	E ₈	F ₇	G ₇
1	3	0 -7	+295 +270	+165 +140	+154 +140	+85 +60	+74 +60	+45 +20	+34 +20	+28 +14	+16 +7	+12 +3
3	6	0 8	+300 +270	+170 +140	+158 +140	+100 +70	+88 +70	+60 +30	+48 +30	+38 +20	+22 +10	+16 +4
6	10	0 -9	+315 +280	+186 +150	+172 +150	+116 +80	+102 +80	+76 +40	+62 +40	+47 +25	+28 +13	+2 +1
10	14	0 -11	+333 +290	+193 +150	+177 +150	+138 +95	+122 +95	+93 +50	+77 +50	+59 +32	+34 +16	+24 +6
14	18	0 -13	+352 +300	+212 +160	+193 +160	+162 +110	+143 +110	+117 +65	+98 +65	+73 +40	+41 +20	+28 +7
18	24	0 -13	+372 +310	+232 +170	+209 +170	+182 +120	+159 +120	+142 +80	+119 +80	+89 +50	+50 +25	+54 +9
24	30	0 -16	+382 +320	+242 +180	+219 +180	+192 +130	+169 +130	+142 +80	+119 +80	+89 +50	+50 +25	+54 +9
30	40	0 -16	+414 +340	+264 +190	+236 +190	+214 +140	+186 +140	+174 +100	+145 +100	+106 +60	+60 +30	+40 +10
40	50	0 -19	+434 +360	+274 +200	+246 +200	+224 +150	+196 +150	+174 +100	+145 +100	+106 +60	+60 +30	+40 +10
50	65	0 -19	+467 +380	+307 +220	+274 +220	+257 +170	+224 +170	+207 +120	+174 +120	+126 +72	+71 +36	+47 +12
65	80	0 -22	+497 +420	+327 +240	+294 +240	+267 +180	+234 +180	+207 +120	+174 +120	+126 +72	+71 +36	+47 +12
80	100	0 -22	+560 +460	+360 +260	+323 +260	+300 +200	+263 +200	+245 +145	+208 +145	+148 +85	+83 +43	+54 +14
100	120	0 -25	+620 +520	+380 +280	+343 +280	+310 +210	+273 +210	+245 +145	+208 +145	+148 +85	+83 +43	+54 +14
120	140	0 -25	+680 +580	+410 +310	+373 +310	+330 +230	+293 +230	+245 +145	+208 +145	+148 +85	+83 +43	+54 +14
140	160	0 -25	+775 +660	+455 +340	+412 +340	+355 +240	+312 +240	+285 +170	+242 +170	+170 +100	+96 +50	+61 +15
160	180	0 -29	+855 +740	+495 +380	+452 +380	+375 +260	+332 +260	+285 +170	+242 +170	+170 +100	+96 +50	+61 +15
180	200	0 -29	+935 +820	+535 +420	+492 +420	+395 +280	+352 +280	+285 +170	+242 +170	+170 +100	+96 +50	+61 +15
200	225	0 -32	+1050 +920	+610 +480	+561 +480	+430 +300	+381 +300	+320 +190	+271 +190	+191 +110	+108 +56	+69 +17
225	250	0 -32	+1180 +1050	+670 +540	+621 +540	+460 +330	+411 +330	+320 +190	+271 +190	+191 +110	+108 +56	+69 +17
250	280	0 -36	+1340 +1200	+740 +600	+689 +600	+500 +360	+449 +360	+350 +210	+299 +210	+214 +215	+119 +62	+75 +18
280	315	0 -36	+1490 +1350	+820 +680	+769 +680	+540 +400	+489 +400	+350 +210	+299 +210	+214 +215	+119 +62	+75 +18
315	355	0 -40	+1655 +1500	+915 +760	+857 +760	+595 +440	+537 +440	+558 +230	+327 +230	+322 +135	+131 +68	+83 +20
355	400	0 -40	+1805 +1650	+995 +840	+937 +840	+375 +480	+577 +480	+558 +230	+327 +230	+322 +135	+131 +68	+83 +20
400	450	0 -40	+1805 +1650	+995 +840	+937 +840	+375 +480	+577 +480	+558 +230	+327 +230	+322 +135	+131 +68	+83 +20
450	500	0 -40	+1805 +1650	+995 +840	+937 +840	+375 +480	+577 +480	+558 +230	+327 +230	+322 +135	+131 +68	+83 +20

BASIC SHAFT SYSTEM
h 6 (cont.)

Diameters		H O L E									
		Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit	Force fit				
From	to	H7	J7	K7	M7	N7	P7	R7	S7	T7	U7
1	3	+9 0	+3 -6	-	0 -9	-4 -13	-7 -16	-10 -19	-13 -22	-	-16 -25
3	6	+12 0	+5 -7	-	0 -12	-4 -16	-8 -20	-11 -23	-15 -27	-	-19 -31
6	10	+15 0	+8 -7	+5 -10	0 -15	-4 -19	-9 -24	-13 -28	-17 -32	-	-22 -37
10	14	+18 0	+10 -8	+6 -12	0 -18	-5 -23	-11 -29	-16 -34	-21 -39	-	-26 -44
14	18										
18	24	+21 0	+12 -9	+6 -15	0 -21	-7 -28	-14 -35	-20 -41	-27 -48	-	-33 -54
24	30										
30	40	+25 0	+14 -11	+7 -18	0 -25	-8 -33	-17 -42	-25 -50	-34 -59	-39 -64	-51 -76
40	50										
50	65	+30 0	+18 -12	+9 -21	0 -30	-9 -39	-21 -51	-30 -60	-42 -72	-55 -85	-76 -106
65	80										
80	100	+35 0	+22 -13	+10 -25	0 -35	-10 -45	-24 -59	-38 -73	-53 -83	-78 -113	-111 -146
100	120										
120	140	+40 0	+26 -14	+12 -28	0 -40	-12 -52	-28 -68	-48 -88	-77 -117	-107 -147	-155 -195
140	160										
160	180	+46 0	+30 -16	+13 -33	0 -46	-14 -60	-33 -80	-60 -106	-105 -151	-149 -195	-219 -265
180	200										
200	225	+52 0	+36 -10	+16 -36	0 -52	-14 -66	-36 -88	-63 -126	-113 -190	-163 -250	-241 -347
225	250										
250	280	+57 0	+39 -13	+17 -40	0 -57	-16 -73	-41 -98	-74 -138	-138 -226	-198 -304	-295 -426
280	315										
315	355	+63 0	+43 -20	+13 -45	0 -63	-17 -80	-45 -108	-78 -130	-150 -202	-220 -272	-330 -400
355	400										
400	450	+63 0	+43 -20	+13 -45	0 -63	-17 -80	-45 -108	-78 -130	-150 -202	-220 -272	-330 -400
450	500										

BASIC SHAFT SYSTEM (h 7)												
Diame- ters	Shaft	H O L E										
		Running fit						Slide fit	Push fit	Wringing fit	Drive fit	Medium force fit
From to	h7	A9	B9	B8	C9	C8	H8	JS	K8	M8	N8	
1 3	0 - 9	+ 29 + 27	+165 +140	+154 +140	+ 85 + 60	+ 74 + 60	+17 0	+ 7 - 7	-	-	- 1 -15	
3 6	0 -12	+ 30 + 27	+170 +140	+158 +140	+100 + 70	+ 88 + 70	+18 0	+ 9 - 9	-	-	- 2 -20	
6 10	0 -15	+ 31 + 28	+186 +150	+172 +150	+116 + 80	+102 + 80	+22 0	+12 -10	+ 6 -10	+ 1 -21	- 3 -25	
10 14	0 -18	+ 33 + 29	+193 +150	+177 +150	+138 + 95	+122 + 95	+27 0	+15 -12	+ 8 -19	+ 2 -25	- 3 -30	
14 18	0 -21	+ 35 + 30	+212 +150	+193 +160	+162 +110	+143 +110	+33 0	+20 -13	+10 -23	+ 4 +29	- 3 -36	
18 24	0 -25	+ 37 + 32	+232 +170	+209 +170	+182 +120	+159 +120	+39 0	+24 -15	+12 -27	+ 5 -34	- 3 -42	
24 30	0 -30	+ 41 + 34	+264 +190	+236 +190	+214 +140	+186 +140	+46 0	+28 -18	+14 -32	+ 5 -41	- 4 -50	
30 40	0 -35	+ 46 + 38	+307 +220	+274 +220	+257 +170	+224 +170	+54 0	+34 -20	+16 -38	+ 6 -48	- 4 -58	
40 50	0 -40	+ 49 + 41	+327 +240	+294 +240	+267 +180	+234 +180	+54 0	+34 -20	+16 -38	+ 6 -48	- 4 -58	
50 65	0 -46	+ 56 + 45	+360 +260	+323 +260	+300 +200	+263 +200	+54 0	+34 -20	+16 -38	+ 6 -48	- 4 -58	
65 80	0 -52	+ 62 + 52	+380 +280	+343 +280	+310 +210	+273 +210	+54 0	+34 -20	+16 -38	+ 6 -48	- 4 -58	
80 100	0 -57	+ 68 + 58	+410 +310	+373 +310	+330 +230	+293 +230	+54 0	+34 -20	+16 -38	+ 6 -48	- 4 -58	
100 120	0 -63	+ 77 + 65	+455 +340	+412 +340	+355 +240	+312 +240	+72 0	+47 -25	+22 -50	+ 9 -63	- 5 -77	
120 140	0 -68	+ 85 + 74	+495 +380	+452 +380	+375 +260	+332 +260	+72 0	+47 -25	+22 -50	+ 9 -63	- 5 -77	
140 160	0 -74	+ 93 + 82	+535 +420	+492 +420	+393 +280	+352 +280	+72 0	+47 -25	+22 -50	+ 9 -63	- 5 -77	
160 180	0 -81	+105 + 92	+610 +480	+561 +480	+430 +300	+381 +300	+81 0	+55 -26	+25 -56	+ 9 -72	- 5 -86	
180 200	0 -87	+118 +105	+670 +549	+621 +540	+460 +330	+411 +330	+81 0	+55 -26	+25 -56	+ 9 -72	- 5 -86	
200 225	0 -94	+134 +120	+740 +600	+689 +600	+500 +360	+449 +360	+89 0	+60 -29	+28 -61	+11 -78	- 5 -94	
225 250	0 -100	+149 +135	+820 +680	+769 +680	+540 +400	+489 +400	+89 0	+60 -29	+28 -61	+11 -78	- 5 -94	
250 280	0 -107	+165 +150	+915 +760	+857 +760	+595 +440	+537 +440	+97 0	+66 -31	+29 -68	+11 -86	- 5 -103	
280 315	0 -114	+180 +165	+995 +840	+937 +840	+636 +480	+577 +480	+97 0	+66 -31	+29 -68	+11 -86	- 5 -103	
315 355	0 -121	+180 +165	+995 +840	+937 +840	+636 +480	+577 +480	+97 0	+66 -31	+29 -68	+11 -86	- 5 -103	
355 400	0 -128	+180 +165	+995 +840	+937 +840	+636 +480	+577 +480	+97 0	+66 -31	+29 -68	+11 -86	- 5 -103	
400 450	0 -135	+180 +165	+995 +840	+937 +840	+636 +480	+577 +480	+97 0	+66 -31	+29 -68	+11 -86	- 5 -103	
450 500	0 -142	+180 +165	+995 +840	+937 +840	+636 +480	+577 +480	+97 0	+66 -31	+29 -68	+11 -86	- 5 -103	

BASIC SHAFT SYSTEM (h8)

Diameters		Static	H O L E									Slide fit
			Running fit									
From	to	h	A9	B9	B8	C9	C8	D10	E9	F8	H8	
1	3	0 -14	+ 295 + 270	+155 +140	+154 + 60	+ 85 + 30	+ 74 + 60	+ 60 + 20	+ 39 + 14	+ 21 + 7	+14 0	
3	6	0 -18	+ 300 + 270	+170 +140	+158 +140	+100 + 70	+ 88 + 70	+ 78 + 30	+ 50 + 20	+ 28 + 10	+18 0	
6	10	0 -22	+ 310 + 280	+186 +150	+172 +150	+115 + 80	+112 + 80	+ 98 + 40	+ 61 + 25	+ 35 + 13	+22 0	
10	14	0 -27	+ 333 + 230	+123 +150	+177 +150	+138 + 95	+122 + 95	+120 + 50	+ 75 + 32	+ 43 + 16	+27 0	
14	18	0 -33	+ 352 + 300	+212 +160	+193 +160	+162 +110	+143 +110	+149 + 65	+ 92 + 40	+ 53 + 20	+33 0	
18	24	0 -39	+ 372 + 300	+232 +170	+209 +170	+182 +120	+159 +120	+180 + 80	+112 + 50	+ 64 + 25	+39 0	
24	30	0 -46	+ 382 + 324	+242 +184	+219 +185	+192 +130	+169 +130	+ 80 + 80	+ 50 + 50	+ 25 + 25	+46 0	
30	40	0 -54	+ 414 + 340	+264 +190	+236 +190	+214 +140	+186 +140	+220 +100	+134 + 60	+ 76 + 30	+54 0	
40	50	0 -63	+ 434 + 360	+274 +200	+246 +200	+224 +150	+196 +150	+100 + 60	+ 60 + 60	+ 30 + 30	+63 0	
50	65	0 -72	+ 467 + 380	+307 +220	+275 +220	+257 +170	+224 +170	+260 +120	+159 + 72	+ 90 + 36	+72 0	
65	80	0 -81	+ 497 + 410	+327 +240	+294 +240	+267 +180	+234 +180	+120 + 60	+ 72 + 60	+ 36 + 36	+81 0	
80	100	0 -90	+ 560 + 460	+360 +260	+323 +260	+300 +200	+263 +200	+260 +120	+159 + 72	+ 90 + 36	+90 0	
100	120	0 -97	+ 620 + 520	+380 +280	+343 +280	+310 +210	+270 +210	+305 +145	+185 + 85	+106 + 43	+97 0	
120	140	0 -100	+ 680 + 580	+410 +310	+375 +310	+330 +230	+293 +230	+260 +120	+159 + 72	+ 90 + 36	+100 0	
140	160	0 -107	+ 775 + 660	+455 +340	+412 +340	+355 +240	+312 +240	+305 +145	+185 + 85	+106 + 43	+107 0	
160	180	0 -114	+ 855 + 740	+495 +380	+452 +380	+375 +250	+332 +260	+355 +170	+215 +100	+122 + 50	+114 0	
180	200	0 -121	+ 935 + 820	+535 +420	+492 +420	+395 +280	+352 +280	+355 +170	+215 +100	+122 + 50	+121 0	
200	225	0 -128	+1050 + 920	+610 +480	+561 +480	+431 +300	+381 +300	+400 +190	+240 +110	+137 + 56	+128 0	
225	250	0 -135	+1180 +1050	+670 +540	+621 +540	+460 +330	+411 +330	+400 +190	+240 +110	+137 + 56	+135 0	
250	280	0 -142	+1340 +1200	+740 +600	+689 +600	+500 +350	+449 +360	+440 +210	+265 +125	+151 + 32	+142 0	
280	315	0 -149	+1490 +1350	+820 +680	+765 +680	+540 +400	+489 +400	+440 +210	+265 +125	+151 + 32	+149 0	
315	355	0 -156	+1655 +1500	+915 +760	+857 +760	+595 +440	+537 +440	+480 +230	+290 +135	+165 + 68	+156 0	
355	400	0 -163	+1805 +1650	+995 +840	+937 +840	+635 +480	+577 +480	+480 +230	+290 +135	+165 + 68	+163 0	
400	450	0 -170	+1955 +1800	+1075 +920	+1017 +920	+735 +580	+677 +580	+520 +260	+325 +165	+195 + 88	+170 0	
450	500	0 -177	+2105 +1950	+1155 +1000	+1097 +1000	+815 +660	+757 +660	+590 +290	+355 +185	+215 + 96	+177 0	

BASIC SHAFT SYSTEM												
h9 & h11												
Diameters		Shaft	H O L E				Shaft	H O L E				
			Running fit					Running fit				
From	to	h9	D10	L9	F8	H8	h11	A11	B11	C11	D11	H11
1	3	0 -25	+ 60 + 20	+ 39 + 14	+ 21 + 7	+14 + 0	0 - 60	+ 330 + 270	+ 200 + 140	+120 + 60	+ 80 + 20	+ 60 0
3	6	0 -30	+ 78 + 30	+ 50 + 20	+ 28 + 10	+18 + 0	0 - 75	+ 345 + 270	+ 215 + 140	+145 + 70	+105 + 30	+ 75 0
6	10	0 -36	+ 98 + 40	+ 61 + 25	+ 35 + 13	+22 + 0	0 - 90	+ 370 + 280	+ 240 + 150	+170 + 80	+130 + 40	+ 90 0
10	14	0	+120	+ 75	+ 43	+27	0	+ 400	+ 260	+205	+160	+110
14	18	-43	+ 50	+ 32	+ 16	0	-110	+ 290	+ 150	+ 95	+ 50	0
18	24	0	+149	+ 92	+ 53	+33	0	+ 430	+ 290	+240	+195	+130
24	30	-52	+ 65	+ 40	+ 20	0	-130	+ 300	+ 160	+110	+ 65	0
30	40	0 -62	+180 + 80	+112 + 50	+ 64 + 25	+39 0	0 -160	+ 470 + 310 + 480 + 320	+ 330 + 170 + 340 + 180	+280 +120 +290 +130	+240 + 80	+160 0
40	50											
50	65	0 -74	+220 +100	+134 + 60	+ 76 + 30	+46 0	0 -190	+ 530 + 340 + 550 + 360	+ 380 + 190 + 390 + 200	+330 +140 +340 +150	+290 +100	+190 0
65	80											
80	100	0 -87	+260 +120	+159 + 72	+ 90 + 36	+54 0	0 -220	+ 600 + 380 + 630 + 410	+ 440 + 220 + 460 + 240	+390 +170 +400 +180	+340 +120	+220 0
100	120											
120	140							+ 710 + 460	+ 510 + 260	+450 +200		
140	160	0 -100	+305 +145	+135 + 85	+106 + 43	+63 0	0 -250	+ 770 + 520 + 830 + 580	+ 530 + 280 + 560 + 310	+460 +210 +480 +230	+395 +145	+250 0
160	180											
180	200							+ 950 + 660	+ 630 + 340	+530 +240		
200	225	0 -115	+355 +170	+215 +100	+122 + 50	+72 0	0 -290	+1030 + 740 +1110 + 820	+ 670 + 380 + 710 + 420	+550 +260 +570 +280	+460 +170	+290 0
225	250											
250	280	0 -130	+400 +190	+240 +110	+137 + 56	+81 0	0 -320	+1240 + 920 +1370 +1050	+ 800 + 480 + 860 + 540	+620 +300 +650 +330	+510 +190	+320 0
280	315											
315	355	0 -140	+440 +210	+265 +125	+151 + 62	+89 0	0 -360	+1560 +1200 +1710 +1350	+ 965 + 600 +1040 + 680	+720 +360 +760 +400	+570 +210	+360 0
355	400											
400	450	0 -155	+480 +230	+290 +135	+165 + 68	+97 0	0 -400	+1900 +1500 +2050 +1650	+1160 + 760 +1240 + 840	+840 +440 +880 +480	+630 +230	+400 0
450	500											

Recommended fits

The tolerances for the bore and outside diameters of rolling bearings are internationally standardised.

To achieve an interference or a clearance fit for bearings with cylindrical bore and cylindrical outside diameter, suitable tolerance ranges for the shaft and housing seatings are selected from the ISO tolerance system. Only a limited selection of the ISO tolerance grades need be considered for rolling bearing applications.

Fig 2 illustrates the location of the most commonly used grades relative to the bearing bore and outside diameter tolerances.

Bearings with tapered bore are mounted either directly on tapered shaft seatings or on slotted sleeves having an external taper (adapter and withdrawal sleeves); the sleeves are mounted on cylindrical shaft seatings. In these cases, the fit of the inner ring is not determined, as for bearings with cylindrical bore, by the selected shaft tolerance but by the distance through which the ring is driven up on its tapered seating or sleeve. Special precautions with respect to the reduction of the internal clearance must be observed (see introductory text of sections "Self-aligning ball bearings" and "Spherical roller bearings"). If the bearings are to be secured using adapter or withdrawal sleeves, larger diameter tolerances are permitted for the sleeve seating but the tolerances for cylindricity must be reduced (see section "Dimensional, form and running accuracy of bearing seatings and abutments").

Tables 1 and 3 on pages 104, 105, 114 and 115 contain recommendations for suitable shaft and housing fits. These recommendations are based on the general selection guidelines described in the above and are valid for solid steel shafts and cast iron or steel housings. Years of practical experience have shown the recommendations to be correct for a very wide range of applications and bearing arrangements. (housing fits) also gives information as to whether the outer ring can be axially displaced. Using this information it is possible to check that the

chosen tolerance is suitable for non-separable bearings which are intended as non-locating bearings.

Degree of interference or clearance

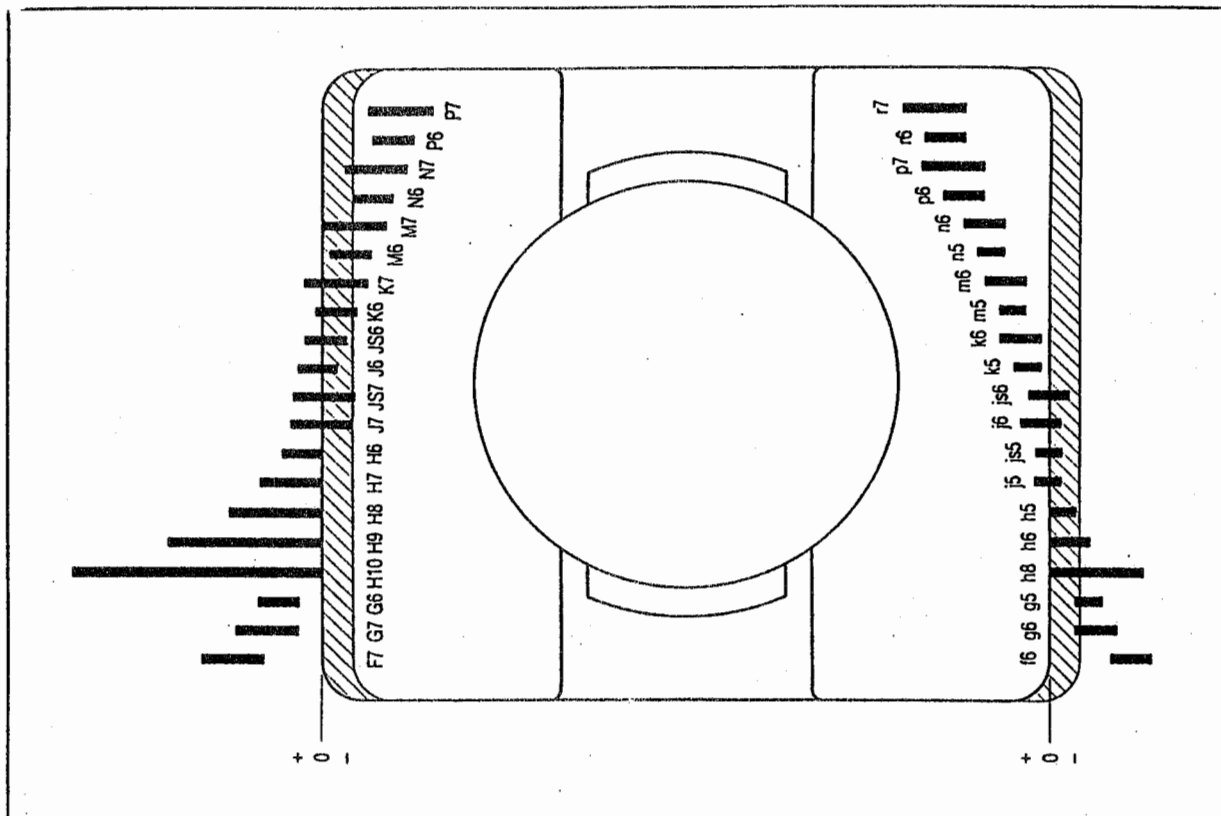
- the upper and lower limits of the shaft and housing bore diameter deviations,
- the smallest and largest values of the theoretical interference (+) or clearance (-) in the fit, and
- the smallest and largest values of the probable interference (+) or clearance (-) in the fit.

The deviations of shaft and housing bore are in accordance with ISO/R 286-1962, where appropriate, and with DIN 7160, DIN 7161 and DIN 7172, part 2.

Values which differ from these in ISO 286-1:1988 and ISO 286-2:1988 have been included by ISO for experimental use only and have not been considered in the tables.

The normal tolerances for the bore and outside diameter (Δ_{imp} and Δ_{Dmp}) for which the limiting values have been calculated are also shown in the table and are valid for all metric rolling bearings with the exception of metric taper roller bearings having $d \leq 30$ mm and $D \leq 150$ mm and thrust bearings with $D \leq 150$ mm. The diameter tolerances for these bearings deviate from the normal tolerances for rolling bearings.

The probable limits cover 99 % of all combinations of theoretical interference or clearance.



ISO-Allowances

Selection

Allowances in $\mu\text{m} = \frac{1}{1000} \text{ mm}$

Nominal size mm over to	External Dimensions (Shafts)											Internal dimensions (holes)																		
	z8°	u8°	u8°	s8	r6°	p6°	n6	k6	j6	h6	h8°	h9	h11	g6	f7	f8°	e8	e9°	d9	c11	a11	H7	H8	H11	G7	F8	E9	D10	C11	A11
1 3	+32	+24	+18	+20	+16	+12	+10	+6	+4	0	0	0	0	-2	-6	-14	-14	-20	-20	-80	-270	+10	+14	+60	+12	+20	+30	+60	+120	+300
3 6	+25	+18	+14	+16	+12	+8	+6	+4	0	-2	-6	-14	-25	-8	-10	-10	-20	-30	-30	-120	-300	+12	+18	+75	+16	+6	+14	+20	+60	+270
6 10	+35	+23	+19	+23	+15	+12	+9	+6	0	-2	-8	-18	-30	-12	-22	-28	-38	-50	-60	-145	-345	0	0	0	+4	+10	+20	+30	+70	+270
10 14	+51	+37	+28	+34	+22	+24	+19	+10	+7	0	0	0	0	-5	-13	-13	-25	-40	-80	-280	+15	+22	+90	+20	+35	+61	+98	+170	+370	
14 18	+42	+28	+23	+23	+19	+15	+10	+1	-2	-9	-22	-36	-90	-14	-16	-16	-32	-50	-50	-250	+18	+27	+110	+24	+43	+75	+120	+205	+400	
18 24	+61	+44	+33	+34	+23	+18	+12	+1	-3	-11	-27	-43	-110	-17	-20	-20	-40	-75	-93	-400	0	0	0	+6	+16	+32	+50	+95	+250	
24 30	+71	+54	+41	+48	+35	+22	+15	+2	-4	-13	-33	-52	-130	-20	-41	-41	-73	-92	-117	-430	+21	+33	+130	+28	+53	+92	+149	+240	+430	
30 40	+86	+61	+48	+54	+41	+28	+17	+2	-5	-16	-39	-62	-160	-25	-25	-25	-50	-88	-112	-480	+25	+39	+160	+34	+64	+112	+180	+250	+460	
40 50	+112	+86	+61	+81	+54	+34	+25	+2	-7	-19	-46	-74	-190	-29	-30	-30	-60	-100	-174	-530	+30	+46	+190	+40	+76	+134	+220	+330	+530	
50 65	+106	+81	+61	+81	+54	+34	+25	+2	-7	-19	-46	-74	-190	-29	-30	-30	-60	-100	-174	-530	+30	+46	+190	+40	+76	+134	+220	+330	+530	
65 80	+121	+96	+76	+96	+61	+41	+32	+3	-9	-22	-54	-87	-220	-34	-36	-36	-72	-125	-159	-600	+35	+54	+220	+47	+90	+159	+260	+370	+580	
80 100	+146	+124	+104	+124	+81	+61	+45	+5	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
100 120	+166	+144	+124	+144	+104	+81	+61	+5	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
120 140	+196	+170	+150	+170	+124	+104	+81	+6	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
140 160	+216	+190	+170	+190	+144	+124	+104	+6	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
160 180	+236	+210	+190	+210	+150	+130	+110	+6	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
180 200	+256	+230	+210	+230	+170	+150	+130	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
200 225	+276	+250	+230	+250	+190	+170	+150	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
225 250	+296	+270	+250	+270	+210	+190	+170	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
250 280	+316	+290	+270	+290	+230	+210	+190	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
280 315	+336	+310	+290	+310	+250	+230	+210	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
315 355	+356	+330	+310	+330	+270	+250	+230	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	
355 400	+376	+350	+330	+350	+290	+270	+250	+7	-11	-25	-63	-100	-250	-38	-40	-40	-80	-145	-207	-770	+40	+63	+250	+54	+105	+185	+305	+460	+770	

MACHINING INDICATIONS .

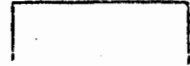
(According to I S A Recommendations)*

The surfacing symbols put on the detail and assembly drawings in the drawing office shall in principle specify only the finish of the surface but not the operations required to obtain such finish .

A) WITHOUT MACHINING ALLOWANCE :

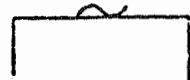
1. Surface left rough , without surfacing symbol:

Surfaces as resulting from the usual non-cutting manufacturing methods as for instance casting , forging , rolling , drawing , pressingetc.



2. Rough machined surfaces , sign of approximation:

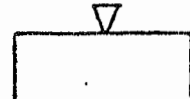
Surfaces as can be obtained through more careful non-cutting manufacturing methods (fine forged , finely flame cut , smoothed in die). Such surfaces are to be machined only if these demands are not fulfilled.



B) WITH MACHINING ALLOWANCE :

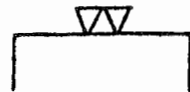
3. Rough machined surfaces , one triangle:

Surfaces are obtained by one or more rough cutting operations , for instance planing , turning , milling , grinding , boring , filing . Fluttings are perceptible to touch and visible to the naked eye.



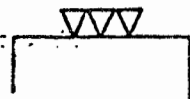
4. Smooth surfaces , two triangles:

Surfaces are obtained by one or more fine cutting operations , for instance planing , turning , milling , grinding , boring , filing , reaming . Fluttings are still visible to the naked eye.



5. Fine smooth surfaces , three triangles:

Surfaces are obtained by one or more cutting operations , for instance planing , turning , milling , scraping , reaming . Fluttings are no longer visible to the naked eye.



C) The surfacing symbols alone give no particulars with regard to the size of the machining allowance(material allowance) , or regarding the size of the tolerances .

D) SURFACING SYMBOLS IN CASE OF FITS & TOLERANCES :

The particulars of fits and tolerances are not sufficient to ensure the production of a certain quality of surface . Therefore , the surfacing sign corresponding to the desired quality of surface , or the necessary instructions in words , must be set at the corresponding surface-line. For example with a coarse fit , a ▽ surface finish is to be chosen if that is sufficient for the surface in quistion . But if the survice requires a smoother surface(for instance for a higher sliding speed) a ▽▽ or a ▽▽▽ surfacing symbol must be adopted even with a coarse fit.

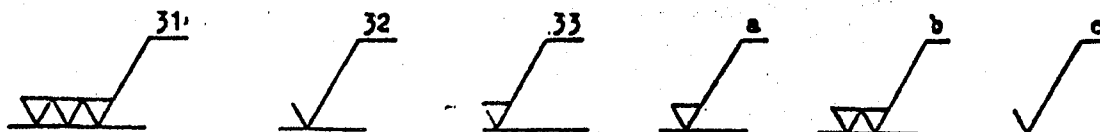
* Equivalent to DIN 140 (Oct. 1931).

E) PARTICULARS CONCERNING SPECIAL MACHINING & SPECIAL TREATMENT :

In addition to the surfaces determined by surfacing symbols \sim , ∇ , $\nabla\nabla$ further special machining and special treatment is required. These are shown on the drawings either by words and the use of reference hook or by words in conjunction with one of the standard surfacing symbols. e.g.



The words in these particulars may also be replaced by numerals or letters. In these cases it is necessary either to accompany the drawing with a sheet of standards giving particulars of the special treatment or to give a list of them on the drawing.



DRAWING SHEET STANDARDS.

According to DIN 476 (April, 1939)

<u>Size Code</u>	<u>Dimension mm.</u>
A ₀	841 x 1189
A ₁	594 x 841
A ₂	420 x 594
A ₃	297 x 420
A ₄	210 x 297
A ₅	148 x 210
A ₆	105 x 148

STANDARD DRAWING SCALES.

According to DIN 823 (Jan., 1956)

1 : 1 , 1 : 2.5 , 1 : 5 , 1 : 10 , 1 : 20 , 1 : 50 , 1 : 100
 1 : 200 , 1 : 500 , 1 : 1000
 2 : 1 , 5 : 1 , 10 : 1

SURFACE FINISH

Assessment of Roughness

Arithmetical Mean R_a

Mean line of the profile m : Line having the form of the geometrical profile and dividing the effective profile so that, within the sampling length, the sum of the squares of distances ($Y_1, Y_2 \dots Y_n$) between effective profile points and the mean line is a minimum.

NOTE - The particular case of the mean line of the profile m is the central line, having the same form as the geometrical profile and located parallel to the general direction of the profile within the sampling length, so that the sums of the areas contained between this line and the effective profile, at both sides of this line, are equal.

Arithmetical mean deviation from the mean line of the profile R_a : Average value of the ordinates ($Y_1, Y_2 \dots Y_n$) from the effective profile to its mean line.

The ordinates are summed without considering their algebraic sign:

$$R_a = \frac{1}{l} \int_0^l |y| dx, \quad \text{approximately:} \quad R_a = \frac{\sum |y_i|}{n}$$

Standard Series of Roughness Numbers

The principal criterion of roughness R_a may be indicated by the corresponding class number shown in the table below

This is to avoid misinterpretation of numerical values which may be indicated in different units, (e.g. micro-metre or micro-inch).

Nominal Values R_a	Micrometre	50	25	12.5	6.3	3.2	1.6	0.8	0.4	0.2	0.1	0.05	0.025
	Micro-inch	2000	1000	500	250	125	63	32	16	8	4	2	1
Roughness Number		N 12	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4	N 3	N 2	N 1







Sampling Length

Numerical values for l . For measuring roughness, the following series of numerical values of the sampling length l is given.

millimetres	inches	millimetres	inches	millimetres	inches
0.08	0.003	0.8	0.03	8.00	0.30
0.25	0.01	2.50	0.100	25.0	1.00

ISO/TC 57 : R 468 - 1966, ISO/TC 10 : DR 1302 - 1967.

SURFACE FINISH Typical Applications

Old Surface Finish Symbol	Roughness Numbers			Typical Applications
	No. ¹⁾	Microns ²⁾	Micro-Inches	
	N 12	50	2000	Smooth non-machined surfaces with nice appearance - Surfaces with no special requirements but to be touched by the hand.
	N 11	25	1000	Non-mating surfaces - Surfaces receiving further machining other than grinding
	N 10	12.5	500	
	N 9	6.3	250	Surfaces taken as datum for subsequent machining - Surfaces to be finished by grinding - Surfaces bolted to a gasket.
	N 8	3.2	125	Normal mating surfaces with no relative motion, no sealing or contact accuracy.
	N 7	1.6	63	Guiding or centring surfaces with occasional relative motion Low speed bearing (sliding) surfaces - Surfaces finished by scraping to form a metal-to-metal joint
	N 6	0.8	32	Accurate centring surfaces without relative motion - Low speed low pressure bearing surfaces
	N 5	0.4	16	Medium speed (up to 3 m/sec) medium pressure (up to 5 kp/cm ²) bearing surfaces - Sliding surfaces with restricted wear.
	N 4	0.2	8	High-speed heavily-loaded sliding bearings - Interior surfaces of hydraulic cylinders - Centring surfaces of fixtures and chucking cones.
	N 3	0.1	4	Ground screw threads and gear teeth - Surfaces for cutting punches.
	N 2	0.05	2	Centring surfaces of high accuracy: main spindles, arbours - Surfaces for cutting dies.
	N 1	0.025	1	Sliding surfaces with extremely low wear - Rolling bearing surfaces - Measuring instruments of high precision.

1) In accordance with ISO DR 1302-1967.

2) Preferred Series of ISO TC/57

SURFACE-ROUGHNESS

Roughness Ra in μm		Examples of use
basic row	practic- al row	
0,008 0,010 0,012	0,012	The smoothest functional surfaces which are to exhibit minimum wear at high specific pressures, e.g. the functional surfaces of the most accurate rolling bearings, the measuring surfaces of the most precise gauges.
0,016 0,020 0,025	0,025	Sliding surfaces with high sliding velocity (over 3m/sec.) and with high unit pressure (over 5kg/cm ²), the wear of which is to be very small; e. g. sliding surfaces of main bearings, pistons, gudgeon pins, antifriction bearings. Measuring surfaces of exact measuring instruments.
0,032 0,040 0,050	0,05	Centering surfaces of main spindles, arbours and tools of high accuracy; sliding surfaces the wear of which is to be very small.
0,063 0,080 0,100	0,1	Exact sliding surfaces of spindles and shafts that are to be in contact and their clearance is to be very small. Ground threads and tooth faces of gear-wheels.
0,125 0,160 0,200	0,2	Surfaces of chucking cones and tools, centering surfaces of fixtures.
0,25 0,32 0,40	0,4	Sliding surfaces with medium sliding velocity (up to 3m/sec.) and with medium unit pressure (up to 5kg/cm ²), the wear of which is to be very small; e.g. sliding surfaces of standard sliding bearings, shifting forks and clutch plates.
0,50 0,63 0,80	0,8	Sliding surface with small sliding velocity and small unit pressure, bearing surfaces for taking up the medium axial pressure. Exact centering surfaces without mutual motion.
1,00 1,25 1,60	1,6	Guiding or centering surfaces with the mutual motion from time to time only.

Contin ...

Continuation of the table

basic	practical row	Examples of use
2,00 2,50 3,15	3,2	Contact surfaces without any mutual motion and without high requirements on the tightness and accuracy of contact. Free surfaces (without function) the outer appearance of which is to be nice.
4,0 5,0 6,3	6,3	Rough machined contact surfaces without mutual motion. Free surfaces that are machined for some reason.
8,0 10,0 12,5	12,5	Rough machines' contact surfaces without mutual motion. Free surfaces (without function), that are machined for some reason.
16,0 20,0 25,0	25	
31,5 40,0 50,0	50	
63 80 100	100	Smooth non machined surfaces the outer appearance of which is to be nice or that are taken in hands.
125 160 200	200	
250 315 400	400	Rough non machined surfaces in which no special requirements are placed.
500 630		

ROUGHNESS OF THE SURFACE

Roughness in μm		Methods of machining						Unmachined surfaces	
over	up to	grinding	broaching	turning	milling	boring plan.	manual work.	casting	forging
0,1	0,2	grain under 80	fine	diam	-	-	-	-	-
0,2	0,4		usual	fine	fine cutter	fine	scraping		-
0,4	0,8								
0,8	1,6				usual		filing	accurate (under pressure etc.)	
1,6	3,2								
3,2	6,3	rough	-		roughing				in forging die
6,3	12,5								
12,5	25								
25	50	-			-		-	into sand	
50	100								

MACHINED SURFACES

Method of finishing and properties of machined surfaces

Surface	Method of finish	Properties and examples of use
Rough +) 12,5-25 ✓	<p>By any method of hand working or machining; filing; planing, turning, milling, drilling, grinding, cold drawing through wire-drawing die.</p> <p>The method of machining is determined according to required accuracy, uniformity, kind of connection, appearance and other requirements.</p>	<p>Machined surfaces with rough touchable and with naked eye clearly visible marks of machine tools (after rough machining with thick chips and great feed). Bearing surfaces which are to bear fully and which need not be accurate in dimensions and smoothness of surface: at bearings, bearing plates, brackets, contact surfaces, which don't move on each other or which are packed with soft packing: at flanges, couplings; surfaces which are not connected with surface of other component parts, e.g. the face of rotating component parts; as at hubs, rims of gears, pulleys; shanks of free-to-go bolts, machined inner free surfaces, holes with great clearance.</p>
Smooth +) 1,6-6,3 ✓	<p>Surfaces at which a certain uniformity is required are machined with working allowance.</p> <p>Without working allowance only at cold drawn material.</p>	<p>Machined surfaces with marks caused by machine tools visible only very little with the naked eye (e.g. after machining by finishing tools with the small thickness of chips).</p> <p>Surfaces, which are to have fine appearance, free surfaces of shafts, connecting rods, cranks; surfaces which bear against each other accurately and don't move: holes in cranks for shaft and pin, centering areas, friction areas of clutches, surfaces which are in contact with belts, ropes brake bands and brake blocks; sliding surfaces for low speed of slide: at rollers, pistons, rams, seat slide valves, bearings; teeth of gears; surfaces which are bright metal coated.</p>
Very smooth +) 0,1-0,8 ✓	<p>By different way of fine machining or hand working which is determined according to required accuracy, connection, appearance, and other requirements. With working allowance.</p>	<p>Machine surfaces without visible marks caused by machine tools. Surfaces where accuracy, smoothness appearance is required and which are to have low friction and wearing out: Teeth of accurate rears, piston rings, accurate pins, spindles with labyrinth packing, accurate tools, component parts of fine mechanics, contact surfaces which are to pack without packings or which are to be rigidly connected; friction areas with high speed of slide: rollers of high-speed machines; pins; shafts in stuffing boxes etc.</p>

+) there are only orientation values.

NON-MACHINED SURFACES

Method of finishing and properties of non-machined surface.

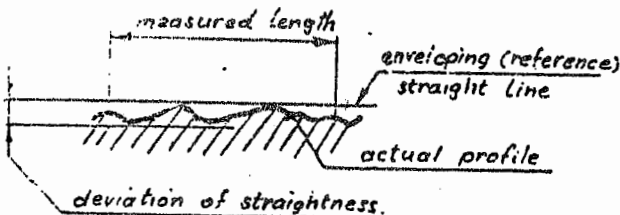
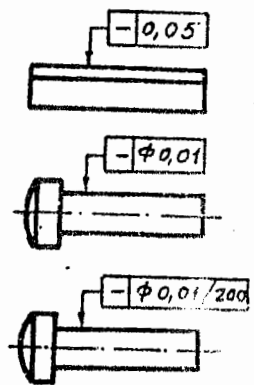
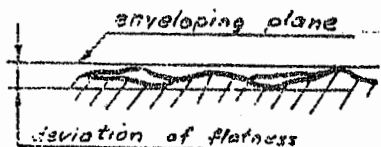
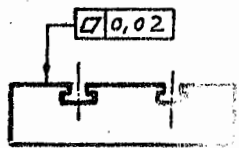
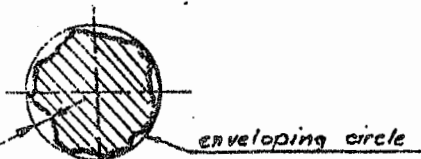
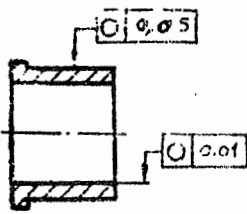

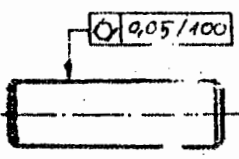
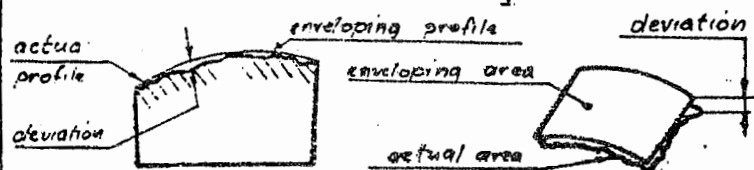
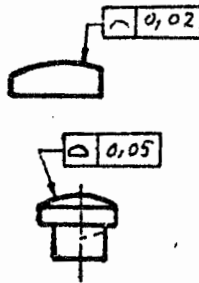
Surface	Method of finish	Properties and examples of use
Rough +) over 100 ✓	<p>The surface of component remains as it has been cast, rolled, pressed. Castings into moulds from common moulding sands.</p> <p>Forgings without use of dies and flat hammers. Without working allowance.</p>	<p>Component surfaces which don't come into contact with surfaces of other components at which the appearance is not important, which need not suit special requirements on smoothness and uniformity and which can be reached by common production, e.g. free surfaces of common casings and forgings for agricultural, brick and mining machines, cranes, bridges; foundation plates for bolts, covered surfaces of frames, stands, etc.</p>
Smooth +) 50-100 ✓	<p>Clean and accurate cast, rolled, forged. Castings cast into fine moulding sand with smooth face, well finished.</p> <p>Forgings forged or die-pressed.</p> <p>Additionally, roughly, as little as possible machined, only in the case when there is necessary to level the surface (by chisel, file, grinding machine)</p>	<p>Non-machined surfaces. Their smoothness is to suit certain requirements (e.g. which are to have nice appearance, or which we hold in our hands), which can be reached by more careful production without any machining: free surfaces of frames, stands, transmission component parts, cut-off devices for pipe lines, hand levers, handles and wheels, inner surfaces of pipes and cut-off devices for pipe lines (to have small resistance).</p> <p>Non-machined surfaces which are additionally and usually hand worked when it was not possible to obtain the required smoothness and uniformity of surface by more careful production without machining; e.g. bearing surfaces of covers, lids, for bolts and nuts on flanges and lugs, casted holes for bolts, surfaces which are dull metal coated (nickle plating, zink coating). Pressed and stamped components, mass produced for motor cars, sewing machines etc.</p>

+) there are only orientation values.

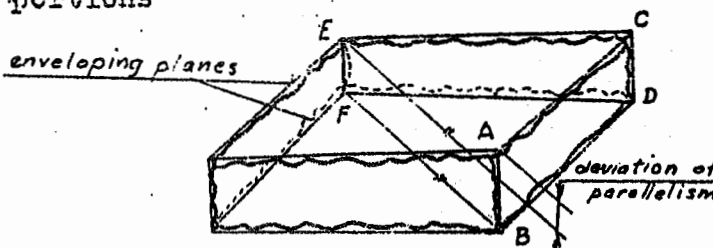
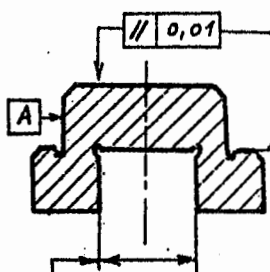
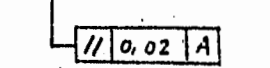
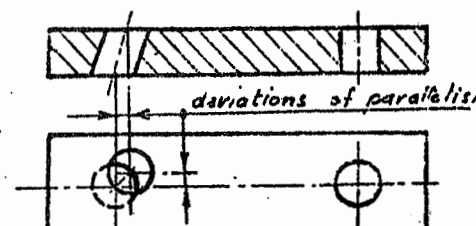
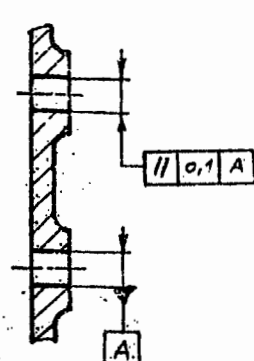
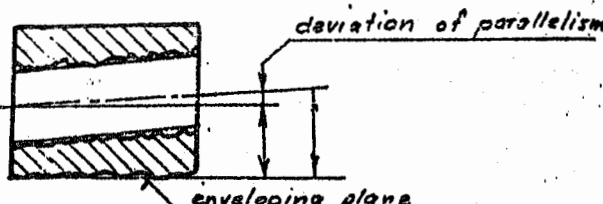
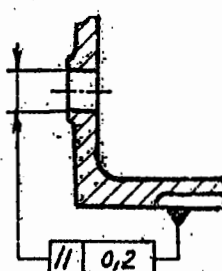
وضع علامات الخشونة على الرسومات الهندسية في النظم الدولية المختلفة


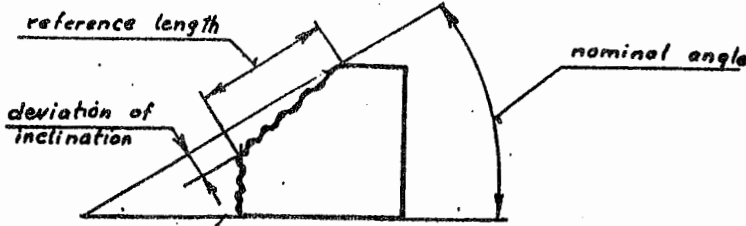
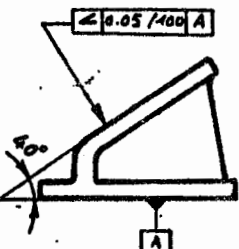

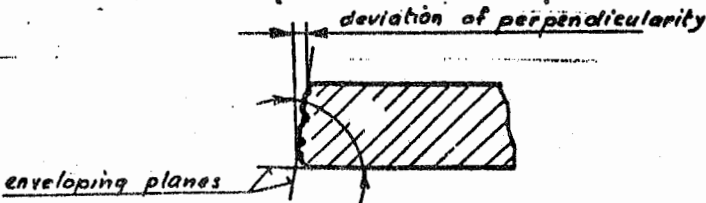
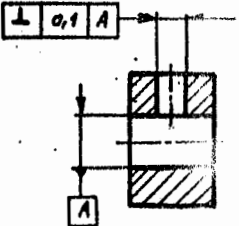

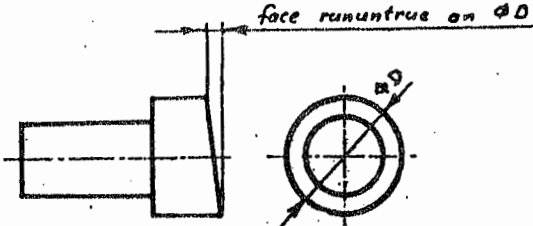
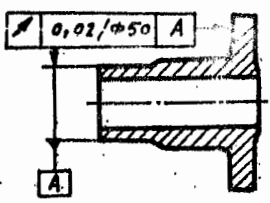

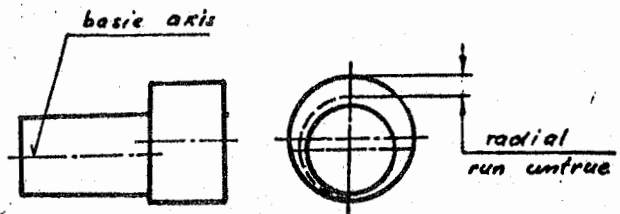
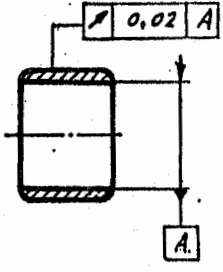
ألمانيا DIN 4762 R_z (μm)	فرنسا AFNOR R_a (μm)	إنجلترا BS1134 R_a (μin)	أمريكا ANSI B46.1 R_a (μin)	الاتحاد السوفيتي GOST 2789/59	تشيكوسلوفاكيا ČSN 0 14450 R_a (μm)	يوغوسلافيا JUS MA0 065	الهند R_a (μm)
$\sqrt{R_z=0.05}$	0.0125	0.5	—	$\nabla 14$	0.0125	1	$R_a 0.0125$
$\sqrt{R_z=0.1}$	0.025	1	1	$\nabla 13$	0.025	2	$R_a 0.025$
$\sqrt{R_z=0.2}$	0.05	2	2	$\nabla 12$	0.05	3	$R_a 0.05$
$\sqrt{R_z=0.4}$	0.1	4	4	$\nabla 11$	0.1	4	$R_a 0.1$
$\sqrt{R_z=0.8}$	0.2	8	8	$\nabla 10$	0.2	5	$R_a 0.2$
$\sqrt{R_z=1.6}$	0.4	16	16	$\nabla 9$	0.4	6	$R_a 0.4$
$\sqrt{R_z=3.2}$	0.8	32	32	$\nabla 8$	0.8	7	$R_a 0.8$
$\sqrt{R_z=6.3}$	1.6	63	63	$\nabla 7$	1.6	8	$R_a 1.6$
$\sqrt{R_z=12.5}$	3.2	125	125	$\nabla 6$	3.2	9	$R_a 3.2$
$\sqrt{R_z=25}$	6.3	250	250	$\nabla 5$	6.3	10	$R_a 6.3$
$\sqrt{R_z=50}$	12.5	500	500	$\nabla 4$	12.5	11	$R_a 12.5$
$\sqrt{R_z=100}$	25	1000	1000	$\nabla 3$	25	12	$R_a 25$
$\sqrt{R_z=200}$	50	2000	2000	$\nabla 2$	50	13	—
$\sqrt{R_z=400}$	100	—	—	$\nabla 1$	100	14	—


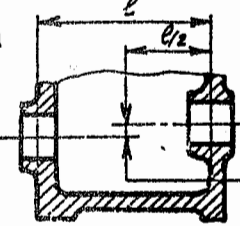
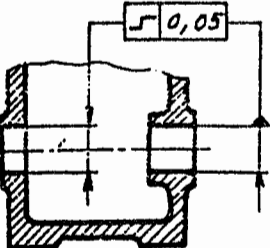

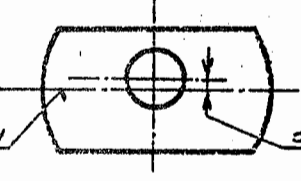
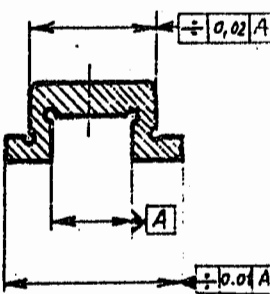

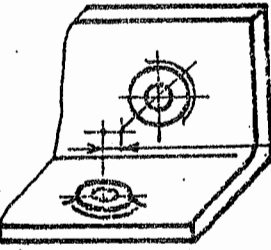
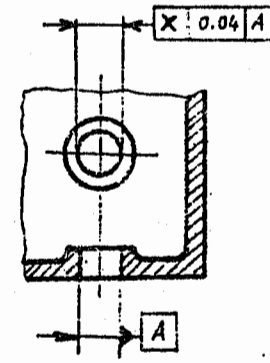

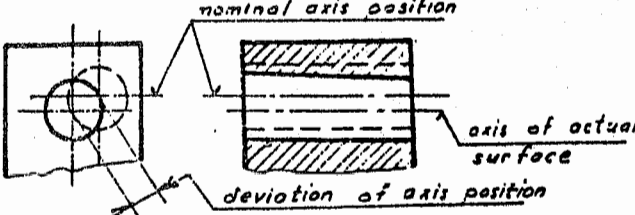
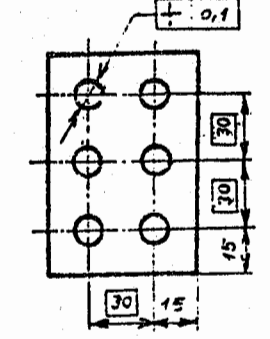
Geometrical Tolerances

Symbol	Definition :	Marking :
—	<p><u>Deviation of straightness</u></p> <p>- the maximum measured distance between the actual line or area and enveloping/reference line.</p> 	
□	<p><u>Deviation of flatness</u></p> <p>- the maximum measured distance between the actual surface and enveloping /reference/ plane.</p> 	
○	<p><u>Deviation of roundness</u></p> <p>- the maximum measured distance between the actual profile and enveloping circle.</p> 	
⊙	<p><u>Deviation of cylindricity</u></p> <p>- the maximum measured distance between the actual cylinder and enveloping cylinder</p> 	
<p>⌒</p> <p>D</p>	<p><u>Deviation of arbitrary shape profile or area</u></p> <p>- the maximum measured distance between the actual profile /surface/ and enveloping profile /area/ of ideal shape.</p> 	

DEVIATIONS OF POSITION :

Symbol	Deviation :	Marking
//	<u>Deviation of parallelism of planes</u> - the difference between maximum and minimum distance of enveloping planes in considered portions 	
	<u>Deviation of parallelism of straight lines in the same plane</u> - the difference between maximum and minimum distance of two enveloping straight lines in the same plane in considered portion 	
	<u>Deviation of parallelism of straight lines in space</u> - the deviations or projections of considered straight lines in two mutually perpendicular planes, one of which is usually led through one of straight lines and through a chosen point of second straight line. 	
	<u>Deviation of parallelism of rotary areas.</u> - the deviation of parallelism of axes of corresponding enveloping areas 	
	<u>Deviation of parallelism of rotary area with flat area</u> - the difference of maximum and minimum distance between enveloping plane and axis of rotary area, in considered portion. 	

Symbol:	Definition:	Marking:
	<p><u>Deviation of inclination</u> - the difference between the actual angle and nominal angle</p> 	
	<p><u>Deviation of perpendicularity</u> - the difference between the actual angle and angle of 90°.</p> 	
	<p><u>Face / axial / runout / rununtrue /</u> - the difference between maximum and minimum measured distance of individual points of actual surface from an arbitrary basic area perpendicular to the axis of rotation measured on prescribed diameter</p> 	
	<p><u>Circumferential / radial / rununtrue</u> - the difference between maximum and minimum measured distance of individual points of actual surface from the basic axis, when rotating the part.</p> 	

Symbol:	Definition:	Marking:
	<p><u>Deviation of concentricity</u></p> <p>- the maximum distance between axis of measured surface and axis of basic area /when skew axes it must be determined place or extend of measurement/ if not specified, it is measured in centre of distance between both areas.</p>  <p><i>deviation of concentricity</i></p>	
	<p><u>Deviation of symmetry</u></p> <p>- the distance between planes of symmetry of shape details under consideration</p>  <p><i>plane of symmetry</i> <i>deviation of symmetry</i></p>	
	<p><u>Deviation of intersection of straight lines</u></p> <p>- the shortest distance of two skew straight lines</p>  <p><i>deviation of crossing of two straight lines</i></p>	
	<p><u>Deviation of position of axes from nominal position</u></p> <p>- the maximum distance of axis/ respectively plane of symmetry/ of actual surface from its nominal position in whole extend of length of checked area</p>  <p><i>nominal axis position</i> <i>axis of actual surface</i> <i>deviation of axis position</i></p>	

GEOMETRICAL DEVIATIONS

Ser.	1	2	3	4	5	6	7	8	9	10	11
Symbol	—	▱	○	⊂	//	⊥	┌	÷	×	↗	↘
Definition	Straightness	Flatness	Roundness	Cylindricity	Parallelism	Perpendicularity	Concentricity	Symmetry	Intersection	Circum. Runout	Face Runout

